During my various changes of venue I accumulated a rich material of Enteropneusta, an account of which I shall shortly publish in Part III. of my Zoological Results which are being issued by the Cambridge University Press.

Lastly, it was my happiness to discover a new type of *Peripatus* in New Britain which differs from the South African, Australasian, and Neotropical subgenera in the same respects—anatomy and development—in which they differ from one another. It constitutes therefore a fourth subgenus, which I have called *Paraperipatus*. With regard to *Peripatus*, the next point of interest centres upon the new species—*P. tholloni*, which has recently been described by Mons. E. L. Bouvier from the Gaboon district (West Africa).

2. On Characteristic Points in the Cranial Osteology of the Parrots. By D'Arcy W. Thompson, C.B., F.Z.S.

[Received November 16, 1898.]

To discover anatomical characters such as might yield or help to yield a natural classification of the Parrots has been the desire of many ornithologists, but the search has availed little. Garrod's abundant work has told us many facts in regard to the presence or absence of an ambiens, of an oil-gland, of one carotid or two, and other varying characters in a multitude of species; but when we come to put these data together the result is unsatisfactory, and one is left with the impression that the several series of facts are incoordinate and cannot be linked together in a single system. When we find, for instance, that the collation of these facts places in a single group *Ara*, *Psittacus*, *Pœocephalus*, and *Nestor*, and in another *Stringops*, *Melopsittacus*, and *Agapornis*, one is tempted to think that the only thing proved is that the data are invalid or antagonistic—in other words, that the several structures had really followed diverse or parallel or convergent lines of modification and evolution. While such internal structures seem to me to lead to confusion by indiscriminate variability, the characters of the skeleton are generally deemed too monotonously alike to present features of significance. Even in *Stringops*, the osteological peculiarities of which are greater than those of any other form (except perhaps *Nestor*), they are yet not conspicuous enough to have prevented certain recent writers from remarking that the divergence of *Stringops* from the other Parrots is not so great as it had been supposed to be.

There is indeed in most parts of the skeleton a very great uniformity throughout the order, but in certain parts, for instance the orbital ring (where the differences are well known, though imperfectly investigated)[1], the hyoid bone (as Dr. St. G. Mivart has shown), the auditory region, and the quadrate bone, there are very numerous conditions to be distinguished, which appear likely to help in the search for natural affinities.

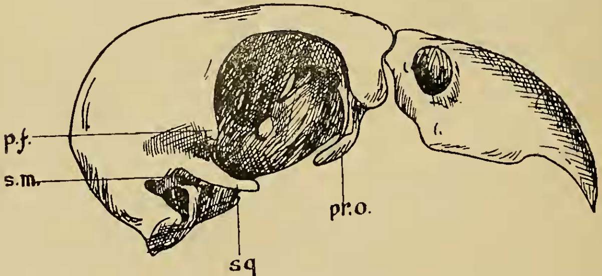
---

[1] *Cf.* Em. Blanchard, "Caractères ostéol. chez les Ois. de la famille des Psittacides," C. R. xliii. pp. 1097–1100 (1856), xliv. pp. 518–521 (1857); C. L. Bonaparte, *ibid.* xliv. pp. 534–539 (1857).

The following pages contain an account of the skull in different genera, with particular reference to three of the above-mentioned characters. The descriptions and figures are taken partly from specimens in my own collection, which is considerable, and partly from skulls belonging to the Royal College of Surgeons and to this Society, for the opportunity of studying which in Dundee I am very greatly obliged to Mr. C. Stewart and to Mr. Beddard. The genera are described for the most part in the order of Count Salvadori's British Museum Catalogue, and I attempt to show in the sequel certain cases where osteology suggests a different arrangement.

The accompanying diagrams of the skull and quadrate of *Psittacus erithacus* (figs. 1 & 2) show the characters to which attention will be chiefly drawn in the descriptions.

Fig. 1.



Psittacus erithacus.

pr.o., preorbital or prefrontal process; *p.f.*, postfrontal process; *sq.*, squamosal *s.m.*, suprameatal tubercle.

From the hinder border of the orbit a process projects downwards and forwards which we may call the *postorbital*, or, as I prefer to call it, the *postfrontal* process: it is also called by Dr. Mivart[1] the sphenotic process. I may remark that this is only one of many cases where we remain in doubt as to what nomenclature to use, for want of knowledge of the facts of embryology. Parker, in his account of the Fowl's skull[2], where this process is not unlike that of many Parrots, describes its development from a separate element, the postfrontal, and it certainly seems to me, from a study of such material as I possess, to be developed both in the Fowl and in Ratites from a frontal or postfrontal element, with which a process of the alisphenoid may be associated. It is sometimes ascribed, as by Gadow[3], to the squamosal bone, which is then said to be continued into *two* lateral processes, and it arises, at any rate, very near the meeting-place of the frontal and squamosal, which may very possibly both be found to contribute to its formation.

---

[1] Mivart, Skeletons of *Lorius* and *Psittacus*, pt. ii., P. Z. S. 1895, p. 363.

[2] Parker, Phil. Trans. 1869, pt. ii. p. 790.

[3] Gadow, Newton's Dict. of Birds, p. 873.

Separated from this postfrontal process by the temporal groove or fossa is the zygomatic process of the squamosal, which it is more convenient to call the *squamosal* process; this, in the Grey Parrot, is the larger and longer of the two. It is seen to be slightly indented below near its apparent origin from the skull, and to jut downwards behind the slight indentation (much more conspicuous in certain other forms) which marks the place where the glenoid cavity for the outer head of the quadrate is excavated below. A slight tubercle projects outwards from, or rather behind, the base of the zygoma, behind the glenoid indentation, and is the *suprameatal* process of Mivart (*l. c.*); between it and the glenoid notch is a small grooved area which in some genera becomes conspicuous. I shall speak of it as the suprameatal area. From the anterior lower margin of the orbit there runs, curving backwards, and crossed near its origin by a well-marked horizontal groove, the *preorbital* or suborbital process, which represents the posterior process of the so-called lachrymal bone. We shall find that the relative size of these processes, their fusion or want of fusion to complete or leave incomplete the orbital ring, and the completion of the orbital ring by union of the lachrymal in some cases with the postfrontal, in some also with the squamosal process, furnish us with several important distinctive characters.

While it is not the object of this paper to deal with the higher morphological questions, I may point out that the so-called lachrymal bone is (at least in my opinion), obviously no lachrymal, but a prefrontal (with which in some cases an inconspicuous lachrymal may be conjoined), as nearly as possible identical in its characters and relations with the prefrontal of the Lizards. The bone in a lizard (e. g. *Iguana*) comes into relation with the frontal, nasal, lachrymal, superior maxillary, jugal, and palatine bones. Its dorsal portion, precisely comparable in most birds to its dorsal ramus in the Lizards, is in relation with the nasal and frontal. Though it does not in any one bird exhibit all the other relations of the lacertilian bone, yet we may discover them severally in one bird or another: in the Snowy Owl, in *Balæniceps*, and in *Podargus* it meets or unites with the maxilla; it comes into relation with the palatine in *Struthio* and *Apteryx*; it meets more or less intimately with the jugal in the Penguins, Petrels, Cormorants, *Gypogeranus*, and others; while in the Raven and many other Passerines, the Penguins, the Guillemots, the Curlew, the Toucan, the Parrots, and many more, it comes into relation with, or fuses with, the ethmoid region, a relation that we cannot seek in the bony skull of the Lacertilia. In Ducks, Geese, and Swans its inferior ramus inclines backwards in the direction of the postfrontal process (the squamosal or zygomatic process being here absent or rudimentary), as it does in the Parrots, and it is said (though I have not actually seen a case) that in certain of these Anserine birds the two unite in a suborbital ring.

In some birds, but not in very many, this bone presents, in its anterior wall, a conspicuous foramen, which is especially well seen, for instance, in *Rhea*, *Struthio*, and *Apteryx*; but it must not at all be confused, as in certain birds it might possibly be apt to be, with the chink formed between prefrontal, frontal, and ethmoid in those birds where the first meets with the last of these three bones: in Parrots this chink is represented by the inner and outer precranial foramina of Mivart, a subdivision already incipient even in the Raven. Where we find the foramen in the Ratitæ, we in most other cases find only a groove on the outer side of the prefrontal, shallow in the Raven and the Parrot, deep in many Passerines, e. g. *Acridotheres*, in *Dacelo*, in the Herons, very deep in the Penguins, the Eagles, Vultures, &c.

It seems to me more than probable that where we have this foramen developed its outer wall is contributed by a true lachrymal, precisely as the similar foramen is bounded by the prefrontal and lachrymal in *Iguana*; but that in the other cases we have good grounds for abandoning the term lachrymal, and accepting the bone in question as a true *prefrontal*[1].

The lacertilian skull gives us no very close parallel to the very remarkable suborbital arcade of the Psittacidæ, but we may trace in it an indication of the latter's constituent parts and probable method of formation. The postfrontal runs in the Lizards, perhaps still more in *Hatteria*, a long way down the inner and anterior side of the superior or ascending ramus of the jugal, that ramus which in birds is aborted, as is the posterior one in the Lacertilia. It is but crossing a very little gap for the prefrontal and postfrontal to join below, and, separating from contact with maxillary and jugal, to form such a suborbital bar as we find in *Stringops*, *Ara*, or *Chrysotis*. And the junction between the two postorbital processes, that is to say the postfrontal and squamosal processes, that we find in the Cockatoos, will be seen simply to enclose a supratemporal arcade, bounded by the same bones and occupied by the same (temporal) muscle as it is in its vastly greater development in the Lacertilia.

The auditory meatus or tympanic orifice is surrounded by an imperfect ring of bone, irregular in outline, of whose real constitution we are again left somewhat in doubt. It seems plain that its upper border is contributed by the *squamosal*, possibly in part by the opisthotic, its outer or posterior border by the thin, shell-like extension of the *exoccipital*, while in regard to its anterior and inferior portions we may assume that they are formed by the *basitemporal* of Parker. Within, this tympanic chamber is produced above into the *superior*, below and behind into the

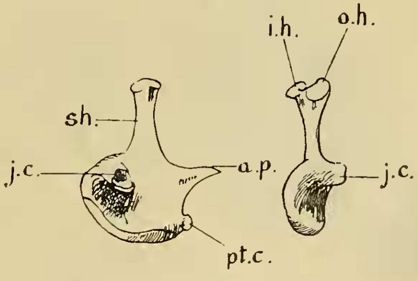
---

[1] In Huxley's 'Anatomy of Vertebrates,' where this bone is described, as usual, as a lachrymal, what is spoken of as the prefrontal is expressly defined as the equivalent of the lateral mass of the ethmoid in Mammals, and the term is thus used in a sense now entirely obsolete.

posterior, below and in front into the long compressed or pointed *anterior tympanic recess*. A bar of bone, part of the proötic, runs forwards near the middle of the cavity, bounding the lower border of the superior recess, and bearing anteriorly the articular surface for the inner head of the quadrate bone, immediately below which is the tiny orifice of the canal for the external ophthalmic artery. Into the posterior recess, below the fenestræ ovalis and rotunda, opens from behind the large aperture which transmits the so-called tensor tympani muscle, and the recess itself runs backwards and downwards externally to the orifice, within the so-called paroccipital process.

In the Grey Parrot the tympanic orifice is moderately wide: looked at from a little to the front it is very nearly semicircular; from a little way behind it appears crescentic, from the manner in which the slightly curving border of the posterior or exoccipital wall encroaches on the front of the cavity. The nearly straight but slightly curving posterior border, the somewhat angular notch above, and the more pointed notch below, that are visible in the figure, are the chief points that catch the eye. We shall find that the shape of the tympanic orifice and the extent to which the cavity is walled in differ much in the different genera, and chiefly in relation to the extent of development of the posterior wall; and that we have great concurrent variation in the area between the auditory meatus and the descending occipital ridge. In some cases, in correspondence with the shape of the quadrate bone, the glenoid cavity for its inner head will be found widely separate, in others scarcely separate or not at all, from the squamosal facet for its outer one. And again the relative dimensions of the recess will be found to vary, the posterior one in particular being sometimes very greatly reduced.

Fig. 2.



Quadrate bone of *Psittacus erithacus*.

i.h., *o.h.*, inner and outer heads; *sh.*, shaft; *a.p.*, anterior process; *j.c.*, jugal cup; *pt.c.*, pterygoid condyle, distinct from and in front of the long mandibular condyle.

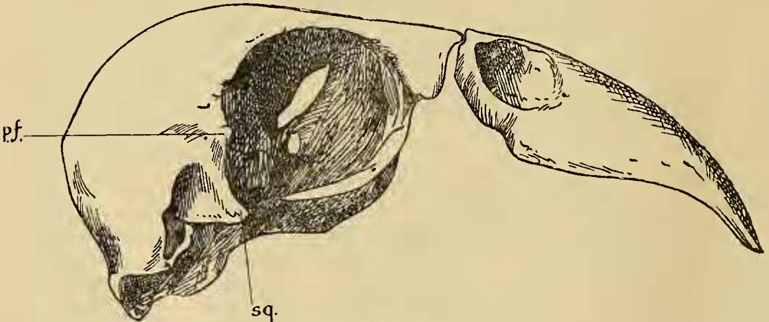
The quadrate bone (fig. 2) shows us a long, straight, slender *shaft*, and a flattened *body*, whose lower margin, almost circular in contour, forms the elongated simple articular surface, playing in the antero-posterior groove that constitutes the unusually simple glenoid cavity of the mandible. In front of this lower articular margin of the quadrate is a small but distinct rounded head or condyle for the pterygoid. An anterior process, small, short, and sharply pointed, runs forwards, at an obtuse angle to the shaft of the bone. The shaft has two heads, the external or squamosal one being large, the inner or proötic one much smaller and separated from the outer by a very shallow groove: a pneumatic foramen enters the shaft on its inner side, below the proötic capitulum. A cup for the quadrato-jugal articulation is directed outwards and forwards, and stands elevated on a tubercular mass of bone, whose posterior surface forms a conspicuous ridge; on the sloping ridge *below* the cup is a small accessory articular surface, which plays against the edge of the mandible (*cf.* Mivart, pp. 374, 391), and whose comparative anatomy is more fully discussed below. We shall find that the quadrate is markedly different from this in *Stringops*; and that in the other genera considerable but less important differences exist in the greater or less separation of the two capitula, the size of the anterior process, the distinctness of the pterygoid condyle, and the conformation of the parts adjacent to the quadrato-jugal cup.

Family NESTORIDÆ.

In all the characters with which this paper is mainly concerned the skull of *Nestor* (figs. 3, 6) is extremely interesting.

The orbit is incomplete. The postfrontal process is rudimentary; the prefrontal process is long, evenly curved, and reaches nearly to the squamosal. The squamosal region is entirely different to that of any other Parrot. The squamosal or zygomatic process, instead of being slender and free on its lower or posterior margin, is continuous with a flattened buttress of bone which connects it with the main body of the squamosal, and which descends

Fig. 3.



Nestor notabilis.

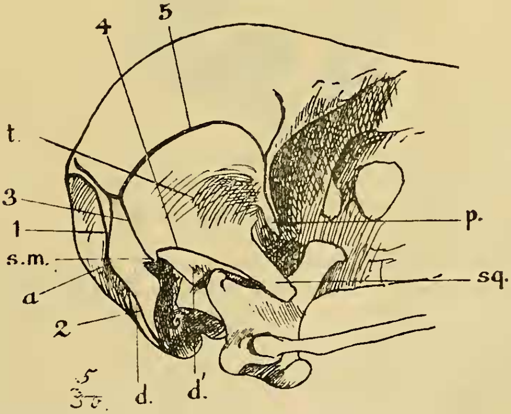
p.f., postfrontal process; *sq.*, squamosal.

in a broad, somewhat excavated shelf to overlap (as well as to project in front of) the head and upper portion of the shaft of the quadrate bone. This squamoso-zygomatic plate is deeply hollowed on its outer face, suggesting perhaps the presence of a highly specialized muscle (probably the second portion of the digastric) originating there. The lower border of the overhanging shelf is slightly bilobed, especially in another specimen in my collection from that figured. The posterior portion or posterior lobe, and perhaps the whole hollow on the outer face of the bone, may be considered to be an extension of the region internal or anterior to the "supra-meatal" process of Mivart, a region which in most Parrots forms only a small facet; its aspect here, together with the general conformation of the bone, reminds us how in a Lizard the squamosal tends to overlap the outside of the quadrate in a way which culminates in the great descending limb or process of the bone that bounds the infratemporal arcade in *Hatteria*.

I know no other bird in which a very similar condition of things is to be seen; but we may discover in some Passerines, *e. g.* the Raven, a certain correspondence of parts.

If we trace in the Raven (fig. 4) the ridges and muscular impressions on the postero-lateral surfaces of the skull, we see (1) on the upper margin of the supra-occipital region two curved trans-

Fig. 4.

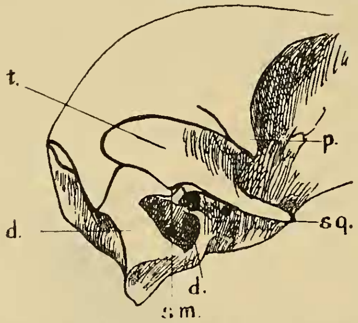


Corvus corax, to show diagrammatically the muscular fossæ and intervening ridges.

s.m., suprameatal tubercle; *sq.*, squamosal; *t.* temporal, *d.* digastric fossa; *d.'*, fossa for second head of the digastric, in front of *s.m.*, the suprameatal tubercle. The ridges or outlines of the muscular impressions are described in the text.

verse ridges which run outwards from the middle line to a tubercle (*a*) posterior to and nearly on a level with the upper border of the auditory meatus; (2) an undivided ridge curves downwards from this point to the outer margin of the paroccipital; (3) springing from the upper of the two supra-occipital ridges, a little way before they reach the tubercle and merge together, a ridge curves downwards to another tubercle (*s.m.*) at the upper and hinder corner of the meatus; and (4) from this latter tubercle a ridge is continued towards the inferior border of the squamosal or zygomatic process; the temporal fossa is bounded above by (5) the great curved line which runs from near the base of the line called 3 to the apex of the postorbital process. These lines separate the following areas or fossæ: I, a narrow triangular area, posterior to the auditory region, which gives origin to the main body of the digastric; II, the temporal fossa, and III, the small space below the line marked 4, which gives origin to the second portion of the digastric muscle. In the Grey Parrot (fig. 5) we can distinguish all these lines and intervening areas; but the digastric area is much broader than in the Raven, owing to the greater extension forwards of the thin posterior wall of the meatus, and the temporal fossa is much longer and narrower. The line 3, between the digastric and temporal fossæ, guides us to its termination in the *suprameatal* process of Mivart, which is thus seen to correspond to the tubercle we have marked *s.m.* in the Raven, in which bird it is some distance behind the glenoid cavity, the intermediate space constituting our fossa III. This last and smallest fossa is excessively small in the Grey Parrot (fig. 6, p. 17), being only represented by a groove between the suprameatal tubercle and the little process of the squamosal internal to it, which descends for a very short distance external and posterior to the head of the quadrate—in other words, which bounds the inconspicuous notch over the head of that bone. To return to *Nestor* (fig. 6), a comparison of the same clearly marked impressions shows us a still larger digastric and smaller temporal fossa, and leads us to recognize the suprameatal process in that one which is now separated widely from the glenoid cavity by the

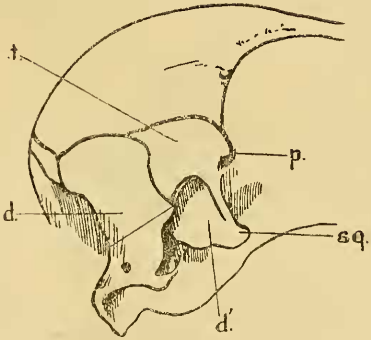
Fig. 5.



Psittacus erithacus, for comparison with fig. 4.
(Letters as in previous figures.)

deep excavation behind the squamosal or zygomatic process which is so marked and exceptional a feature in this bird, but which we now discover to be a huge development of the tiny groove in *Psittacus*, and of our IIIrd fossa in *Corvus*; and we further see that the opposite or inner wall of this last fossa, which so deeply overlaps and overhangs the head and shaft of the quadrate, is precisely comparable to that little process which did likewise, but to a slight degree, in the Grey Parrot and the Crow.

Fig. 6.

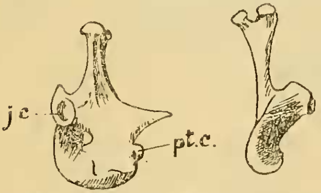


Nestor meridionalis, for comparison with figs. 4 & 5.
(Letters as in previous figures.)

The tympanic cavity is of moderate size, widely open when we look at it from in front, but in its lateral aspect almost concealed by the forward growth of the scroll-like posterior wall; the cavity has a deep posterior recess, descending to near the apex of the paroccipital process, where is a large oval foramen for the so-called tensor tympani. The lower and anterior border of the meatus, as it bends upwards, quite distinctly shuts out the region of the quadrate articulation from the boundaries of the tympanic cavity.

The quadrate bone (fig. 7) has two widely separate capitula, the inner one being in a considerable degree the smaller; but the double socket for these heads, though constricted in the middle,

Fig. 7.



Quadrate bone of *Nestor meridionalis*.
(Letters as in previous figures.)

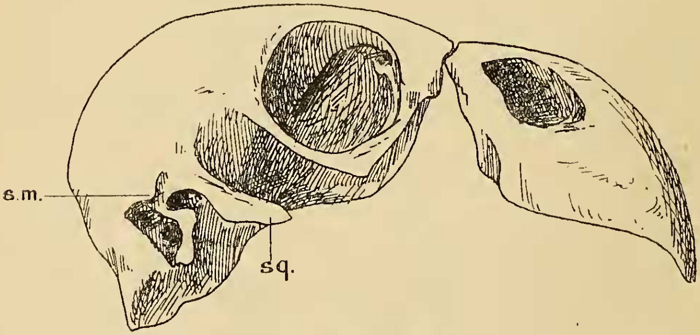
is continuous and not divided into two. The pterygoid condyle is well-marked, and more distinctly separate than usual from the long mandibular condyle. The chief peculiarity in the bone is in the region of the quadrato-jugal cup, which is more than usually elevated from the flat surface of the bone, the tubercular mass on which it stands being produced above into a sharp ridge, and being directed outwards or even a little backwards instead of forwards, as is commonly the case. The whole under surface of this protuberance, together with the outer face of the body of the bone down to the condyle, plays on a corresponding articular surface on the inner wall and edge of the mandible. In one of my specimens of *Nestor* the jugal sends up a short but distinct rudiment of an "ascending ramus."

There are many other points of more or less importance, but many of which I must pass over, to be noted in the skull of *Nestor*. The nasal apertures are oval and very large, and are hollowed out in front into a broad shallow depression. On the base of the cranium the ridges which run their divergent course from below the median Eustachian orifice to the paroccipital process are very high. whereas in *Psittacus* they are feeble, and the well-marked surface or area external to them is much more flat and approximately horizontal in the latter bird. The angle of the mandible is pointed and very elongate, and the foramen, or rather fontanelle, in the middle of the mandibular ramus is oval and very large.

Family Stringopidæ.

The skull of *Stringops* (figs. 8, 9) is very remarkable, only less so on the whole, and more so in some respects, than that of *Nestor*.

Fig. 8.



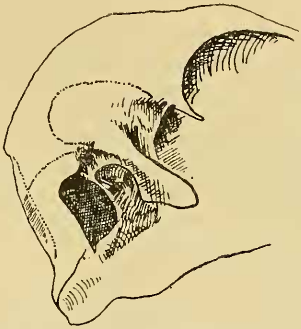
Stringops habroptilus.

(Letters as in previous figures.)

The orbit is complete (in the adult) by union of the prefrontal with the postfrontal; in other words, the orbit of *Stringops* is unlike that of any other Old-World Parrot, and resembles that of

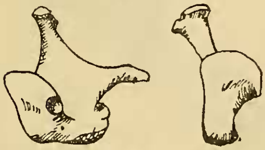
Chrysotis and the Macaws. The orbit is of remarkably small size, its antero-posterior diameter being about equal to that of *Psittacus erithacus*, and a little less than that of *Eclectus cardinalis*. The squamosal process is large and flattened; it runs parallel to the posterior portion of the suborbital ring, and the temporal fossa between is unusually deep and wide. The suprameatal process is large, and overhangs a deep groove or hollowed plate of bone that lies posterior to the quadrate articulation and above the auditory meatus, roofing over the superior auditory recess; it is comparable to, though far smaller than, the remarkable area connecting the auditory cavity with the hollowed surface of the squamosal in *Nestor*. The anterior border of this bony plate forms a well-defined margin to the quadrate articulation, which is thus very distinctly separated from the auditory cavity. The auditory meatus is rounded and wide open; its posterior wall scarcely diminishes its aperture. The basitemporal plate is on a level with the occipital condyle; its edges are formed by elevated ridges that run back to the nearly vertical paroccipitals, and the lateral areas continued forwards from these latter are sharply inclined. The intraorbital vacuities are very large. The quadrate bone (fig. 10) is especially remarkable, and in it the Psittacine type of quadrate is imperfectly attained. The shaft of the bone is shorter and less vertical than usual, the

Fig. 9.



Stringops habroptilus: part of the skull of a young individual, for comparison with figs. 4, 5, 6.

Fig. 10.



Quadrate bone of *Stringops*.

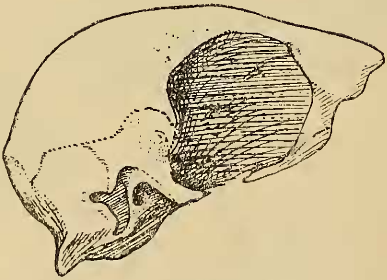
anterior process much larger and blunter, the whole body of the bone more expanded, and the glenoid surface more elongate and less curved. The pterygoid condyle is independent, and set about halfway between the main condyle and the base of the anterior process. The quadrato-jugal cup looks nearly forwards, and is set on a powerful ridge of bone that forms a sharp free edge as we look at it from the hinder or outer sides. Immediately below the quadrato-jugal cup, on the underside of the prominent ridge, is an articular facet which plays on a corresponding surface on the edge of the mandible. The inner head of the quadrate bone is comparatively large and imperfectly separated from the outer one. The descending processes on the hinder border of the maxillæ are large. The usual mandibular fenestra is obsolete, but a small one is present (represented in a good many other forms by a small foramen) apparently between the articular and splenial elements. I have not seen a complete hyoid, and can only say that the parahyals are uncommonly large and point upwards.

The skull of *Stringops* represented in fig. 9 is that of a young or half-grown individual, in which the orbit is still incomplete. The circumstance is natural enough, but it may serve to remind us that the completeness or incompleteness of the orbit is not, after all, a very deep-seated morphological difference; it is merely a case of greater or less extension of ossification in a ligamentous connection that is already there.

Family Loriidæ.

Dr. Mivart has lately given us a copious description of the skeleton of *Lorius flavopalliatus*. My account shall deal only with the points that seem to me of chief importance. I have studied four forms, *Eos riciniata*, *Lorius domicella* (fig. 11), *Trichoglossus ornatus*, and *Glossopsittacus*, sp.; these are all so similar in their main features that their descriptions may be incorporated together.

Fig. 11.



Lorius domicella (slightly enlarged).

The postfrontal process is in all of them small, largest in *Eos*, and least in *Lorius*. It is in the form of a nearly vertical ridge with a very short free extremity, and the fossa for the temporalis muscle is seen to extend upwards behind it, instead of being merely overhung by it as in *Psittacus*. The squamosal process is well developed, rather long and pointed at the end; it is somewhat shorter and broader in *Lorius* than in the others. The posterior ramus of the prefrontal is well developed and extends behind the middle of the orbit; but it does not create a suborbital ring, though, especially in *Trichoglossus* and *Eos*, it may come very near to the squamosal.

The posterior wall of the tympanic cavity is formed after the fashion of *Psittacus*, but leaves an aperture of an apparently different shape, by reason of the greater forward growth of its middle portion, so that the crescentic form of the aperture, or rather the development of a conspicuous notch below and another above and posteriorly, is better marked. The latter or upper notch is just below and behind the suprameatal tubercle. The anterior wall of the tympanum shows (in all four genera) an ascending bar or splinter of bone that walls off from the tympanic cavity the articulation of the quadrate. This is a little point of resemblance to *Nestor*, but it is the only one I can detect, and unsupported it goes for nothing. The groove or area in front of the suprameatal process is well-marked; it is very much more extensive than in *Psittacus*, for it extends into an excavated surface on the squamosal process, reaching well in front of the glenoid notch. The jugular foramen is exceedingly small, and the posterior recess of the tympanum not large.

The quadrate has two deeply separated heads; the inner one is very small and bent inwards almost perpendicularly to the shaft. The two sockets on the squamosal and proötic elements are distinctly and rather widely separate, and the latter is a small deep hollow.

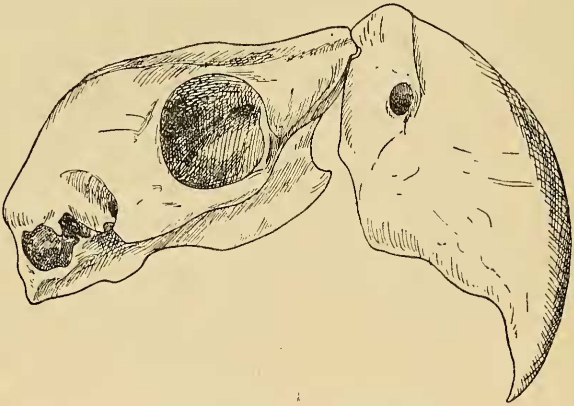
The mandibular fontanelle is a minute orifice placed much further back than in *Psittacus*. The basitemporal ridges are better marked than in *Psittacus*, but they distinctly terminate below the foramen for the vagus, and are separated by a notch from the succeeding ridge which marks the under border of the paroccipital. It is true that both in *Nestor* and *Psittacus* there is at the same point a slight change of direction and appearance of discontinuity, but, especially in the former skull, the ridges are nearly continuous.

Family CACATUIDÆ.

The Cockatoos possess certain cranial characters in common and their skulls are easily to be recognized, but there are many variations within the family and even within the restricted genus *Cacatua*.

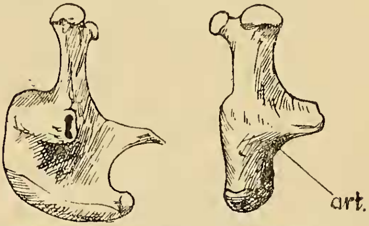
The orbital ring is complete by union of the prefrontal and postfrontal bones, and from the hinder part of the suborbital bar thus formed a strong process runs backwards to fuse, in most cases though not in all, with the squamosal process, and thus (as has been mentioned above) to bound a supratemporal fossa. We do not know whether this process is actually developed as a mere continuation of the prefrontal or as a posterior offshoot of the postfrontal, because postfrontal and prefrontal are in all Cacatuidæ intimately fused; but I am inclined to anticipate that examination of young individuals would show it to be an outgrowth of the postfrontal, and to correspond precisely to the posterior or squamosal ramus of that bone in the Lacertilia.

Fig. 12.



Microglossus aterrimus (reduced).

Fig. 13.



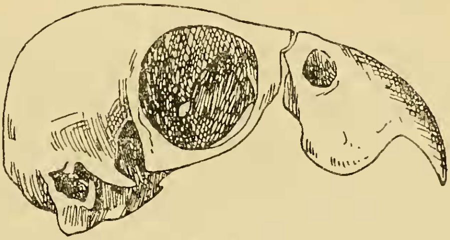
Quadrate bone of *Microglossus aterrimus.*

art., the accessory articular surface beneath the jugal cup for articulation with the edge of the mandible.

The only Cockatoos in which I have observed this supratemporal fossa to remain incomplete are *C. ducorpsi* (fig. 14) and *Microglossus aterrimus* (fig. 12), and here we appear to have the posterior outgrowth or ramus of the postfrontal developed, though not to such an extent as to fuse with the squamosal process. Blanchard (C. R. 1856, p. 1098) says the same of *Calyptorhynchus xanthonotus*, but in *C. banksi* (fig. 10), which I have examined, the fossa is complete and the whole region much as in other Cockatoos.

In *Cacatua* the auditory meatus is somewhat narrowed, much as in *Psittacus*, but to a varying degree in different species. In *C. roseicapilla* the ingrowth of the posterior wall is particularly well marked, and leaves a large circular notch above, where in *Ps. erithacus* we had a more pointed indentation; in *C. gymnopus*, on the other hand, the posterior margin is convex rather than concave: but though less marked in *C. roseicapilla* than in the rest, it is very characteristic of the Cockatoos that the region between the descending occipital ridge and the posterior wall of the auditory meatus is extremely narrow. We shall see that this, which perhaps deserves to be spoken of as the digastric area, differs greatly in extent in the different groups of Parrots. The suprameatal tubercle is distinct, and the triangular area below and in front of it is larger than in *Psittacus*. The region of the squamosal process overlapped by the fused posterior ramus of the prefrontal forms in *C. roseicapilla* a prominent projection extending backwards and downwards to overlap the shaft of the quadrate bone; but in *C. leadbeateri* and *C. ducorpsi* this is not the case, the posterior or inferior margin of the squamosal process running evenly forward and downward as in *Psittacus*. The paroccipital processes are large and point somewhat backwards; the basitemporal ridges are prominent, but not continued directly on to the under surface of the paroccipital. The occipital condyle is considerably above the level of the base of the skull. The mandibular fontanelle is very small or obsolete. The paroccipital is but slightly excavated within; the jugular foramen is small, except in *C. ducorpsi*, where it is considerably bigger. The two facets for the heads of the quadrate bone are distinctly separated by a ridge. The two heads of the quadrate are wide apart, and the inner is rather large, more than half as large as the outer. The pterygoid condyle is distinct, and in *C. roseicapilla* is more distinct than in the others from the main condyle or mandibular articulation. The shaft of the quadrate is distinctly stouter than in *Psittacus*, and the upper posterior portion of the body above the quadrato-jugal cup is not rounded off as in that genus, but conspicuously prominent.

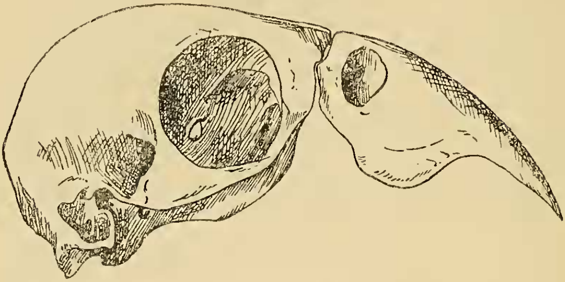
Fig. 14.



Cacatua ducorpsi.

The skull of *Licmetis* (fig. 15) has certain peculiarities. The postfrontal process is exceedingly broad, both in its descending and its posterior ramus, and the supratemporal fossa is accordingly restricted in size. The tympanic cavity is wider open than in the others, the posterior wall encroaching little; in this respect it resembles the skull of *C. roseicapilla*. The inner head of the quadrate is exceptionally large. The paroccipital processes are rather short but very large, and looked at from behind form a *transverse* ridge; the area below them and between the meatus and the basitemporal ridges is very well defined, constricted in the middle into a peculiar shape by the lower notch of the meatus and the interruption between basioccipital and paroccipital ridges, and nearly horizontal. The angle of the mandible is more elongate and pointed than in the other Cockatoos.

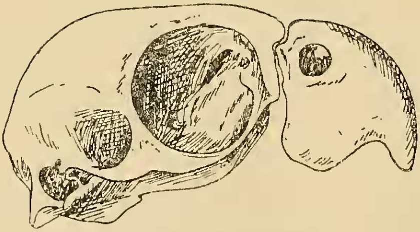
Fig. 15.



Licmetis nasica.

In *Calyptorhynchus banksi* and *Callocephalon galeatum* (fig. 16) the orbital ring is formed in the manner characteristic of the Cockatoos, and the region of the squamosal process sends off no projecting lobe such as I have described in *C. roseicapilla*. In *C. galeatum* the supratemporal fenestra is wide, and the surface for the origin of the temporal muscle exceptionally large, extending far back on to the posterior surface of the skull. The

Fig. 16.



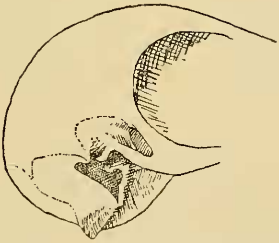
Callocephalon galeatum.

auditory meatus in both is wide, and its posterior border concave. The paroccipitals are prominent, pointed, and directed backwards, without forming the transverse projection and ridge of *Licmetis*. The basitemporal ridges run nearly continuously on to the paroccipital, and the surface external to them is inclined outwards. The shaft of the quadrate is very stout. In *Callocephalon* the two heads of the bone are only separated by a very narrow and shallow groove. In both genera the angle of the mandible is rounded and truncate.

In *Microglossa* the squamosal process fails to join, though it projects a little way under, the suborbital ring; it is exceedingly small and pointed. The posterior or postorbital region of the suborbital bar is very large and broad, and sends back a posterior lobe from its lower angle. The temporal fossa is very small, scarcely larger than in *C. roseicapilla* and much less than in *C. leadbeateri*. The auditory meatus is wide open, its aperture approximately oval. The paroccipital process is large; looked at from behind its posterior border is nearly vertical, but its angle projects somewhat posteriorly; it is very little hollowed within, and the jugular foramen is very small; the basitemporal ridges run almost uninterruptedly into the deeply compressed lower border of the paroccipital. The articular facets for the quadrate are separated by a well-marked groove, and are walled off from the tympanic cavity by a splinter of bone. The quadrate has two deeply separate heads, the inner one scarcely half the size of the outer; its other characters are those of the family; the extra facet below the quadrato-jugal cup is small and deeply marked. The angle of the shaft is short and bluntly pointed; the mandibular fenestra is obsolete. In the skull the inner wall of the orbit is scarcely perforate in front of the orbital foramen; the jugal bone is notably expanded at its anterior end.

The skull of *Calopsittacus* (fig. 17) is similar to that of the Cockatoos in having the orbital bar completed by junction both with postorbital and with squamosal, which leave between a rather elongated supratemporal vacuity. The auditory meatus is narrower than in the Cockatoos, and its posterior and inferior notches are

Fig. 17.



Calopsittacus novæ-hollandiæ (enlarged).

well-marked. The quadrate articulation is scarcely separated in the dry skull from the tympanic cavity. The "suprameatal area" is rather large and faces outwards; it is in fact unusually conspicuous, though vastly less developed than in *Nestor*. The inner head of the quadrate is small, widely separate from the outer, and bent sharply inwards; the pterygoid condyle is imperfectly separate from the mandibular. In the mandible the marginal surface of articulation with the body of the quadrate is very conspicuous, and the edge of the mandible is here bent outwards. A small mandibular fontanelle is present; the angle of the jaw is short but pointed. As in Cockatoos generally, the interorbital vacuity is small and rounded. In one point, not among those chiefly considered in this paper, the skull of *Calopsittacus* differs from its congeners: between the anterior rami of the palatines there are visible (as in *Psittacus*) two long processes descending from the posterior portion of the maxillary bones; these are the "median processes of the inferior margin of the postaxial surface of the prosopium," in Dr. Mivart's description of *Psittacus*. They are, as a rule, small or obsolete in the other Cacatuidæ. It is clear that the skull of *Calopsittacus*, though at first sight very similar to, is different in several respects from, the true Cacatuine type. It is possible that these differences involve resemblances to the *Platycercini*, and this question will be further discussed below.

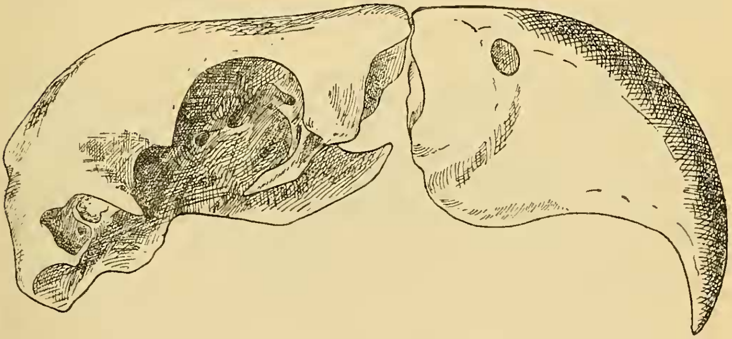
Family NASITERNINÆ.

I have examined the tiny skull of *N. pygmæa* in an example unfortunately not full-grown, belonging to the Museum of the R. College of Surgeons. It is impossible to rest much weight on this beautiful but imperfect little skull. The orbit is exceedingly incomplete, the prefrontal process being very short (the prefrontal bone is not yet quite co-ossified with the frontal, and is in close connection for an almost equal extent of contact with the nasal). The postfrontal process is also small and scarcely prominent; the squamosal process, on the other hand, is long and slender and directed obliquely downwards. The posterior border of the auditory meatus is nearly straight. The suprameatal tubercle and its subjacent groove are both well marked.

THE MACAWS.

The great Blue Macaws differ, as is well known, from the rest in certain of their cranial characters. In *Anadorhynchus hyacinthinus* (fig. 18, p. 27) the orbit is incomplete, the prefrontal process terminating in a sharp point below the middle of the orbit. The postfrontal process is of moderate size, short but massive; the squamosal process is rather small, and united nearly to its tip on the inner side by a bridge of bone to the edge of the temporal fossa. The auditory meatus is wide and approximately square in outline; the posterior and superior recesses of the tympanic cavity are scarcely excavated, and the partition between the cavity and the quadrate articulation is scarcely visible in the dry skull. The squamosal and proötic articular surfaces are both wide, and are separated by a deep groove, though in the quadrate bone itself there is but a shallow groove between the two heads. The shaft of the quadrate is longer and less massive than in the Cockatoos; the quadratojugal cup and the pterygoid condyle are both large; the anterior or orbital process is long and attenuated. The paroccipital wings are largely developed, and run almost uninterruptedly below into the basitemporal ridges. The posterior view of the skull is very similar to that of *Microglossa.* On the dorsal border of the foramen magnum can be detected two small articular facets: these are produced by contact with the unusually developed spine of the axis vertebra; in *Microglossa*, on the other hand, two small subordinate facets are present on either side of the occipital condyle.

Fig. 18.

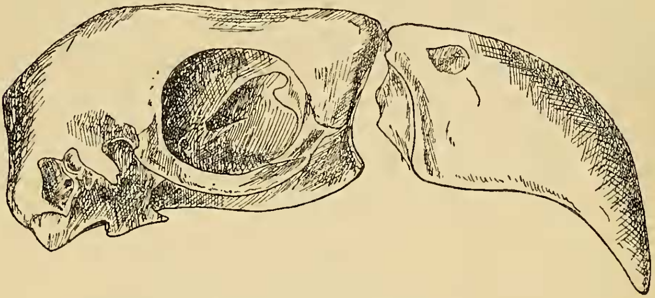


Anadorhynchus hyacinthinus (reduced).

In the Hyacinthine Macaw the anterior margin of the interorbital septum is deeply notched, the lower portion running forward like a curved and pointed blade. The anterior region of the cranium, on either side of the upper portion of the septum, is hollowed out into two immense and deep cavities, which are scarcely represented in the other Macaws; indeed, in this region, and on the corresponding opposite face of the "prosopium," there are many interesting characters to be recognized that lie beyond the scope of this paper. The jugal bone is compressed from above downwards at its anterior extremity, instead of from side to side as in *Microglossa.* The angle of the mandible is obtusely truncated; the ramus presents no mandibular fontanelle; the accessory marginal articulation for the quadrate is large, elongate, and connected by a smooth surface with the main articulation.

Of the other Macaws, I have examined *A. ararauna*, *chloroptera* (fig. 19, p. 28), *macao*, and *maracana.* That of *A. ararauna* is remarkable in having the orbital ring incomplete, though the long curved prefrontal processes approach very close to the postfrontal; it is complete in the others, and its posterior portion is somewhat broad and flattened, especially so in *A. macao*, where the broadened hinder region forms an obtuse postero-inferior angle.

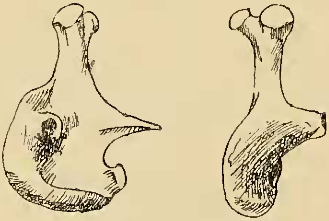
Fig. 19.



Ara chloroptera (reduced).

The squamosal process is least developed in *A. ararauna*, most so in *A. maracana*. The paroccipital wings are largest in *A. chloroptera* and *macao*. The auditory meatus is widest in *A. chloroptera* and *maracana*; it is considerably narrowed, and shows a slightly projecting lower lip and a well-marked postero-superior notch in *A. ararauna*; and in *A. macao* it is very remarkably narrowed, partly by the growth forwards of the posterior wall, and still more by the growth backwards of the anterior, which overlaps the lower part of the orifice as a broad tongue of bone. The two heads of the quadrate (fig. 20) are in all more widely separate than in *A. hyacinthinus*. The anterior margin of the infraorbital septum is squarely truncate in *A. ararauna*; it tends in the others, and especially in *A. macao*, to curve forward in the same manner as, though in a less degree than, in *A. hyacinthinus*.

Fig. 20.



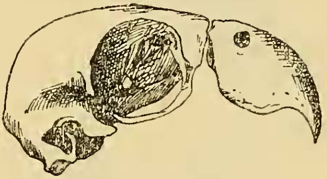
Quadrate bone of *Ara chloroptera*.

The mandible is narrowest from side to side in *A. ararauna*, and in this respect least like that of *A. hyacinthinus*. In the same species the articular groove for the quadrate is nearly straight antero-posteriorly, while in the others, as in *A. hyacinthinus*, that of each side converges inwards: in the same species the angle is somewhat less truncated than in the others, and the facet for the insertion of the depressor muscle smaller, more rounded, and not ascending, as in the rest, on the posterior margin of the bone.

THE CONURES.

Excluding the Macaws, I have examined of the other Conuridæ, *Conurus*, *Pyrrhura*, *Myopsittacus*, and *Brotogerys*. The skulls of the first differ from those of the last two materially. In *Conurus* I have found the orbital ring complete in *C. leucotis*, but incomplete in *C. æruginosus* (fig. 21) and *C. hæmorrhous*: in both of the latter, however, the imperfection is but slight, the prefrontal process running backwards nearly to contact with the postfrontal. The squamosal process is somewhat stout, and curves forward in the direction of the orbital ring; its lower border forms a marked notch over the region of the quadrate articulation. The auditory meatus is considerably wider in *C. hæmorrhous* than in the other two species, and the upper and lower notches are accordingly better marked in the latter. The inner head of the quadrate is of considerable size; the anterior process is very slender; the posterior angle of the bone is reduced, and the articular surface runs up abruptly to end in a prominence on a level with the base of the shaft, making the outer surface of the bone appear narrower than usual; but this last character is much less marked in *C. hæmorrhous* than in the others. The paroccipital wings and basitemporal ridges are well developed. The supra-occipital is markedly tumid in the region of the middle lobe of the cerebellum. The mandible is extremely short and broad, and its fontanelles are obsolete. The descending processes from the hinder border of the maxilla are very well developed in *C. hæmorrhous*, but not so in the other two species.

Fig. 21.



Conurus æruginosus.

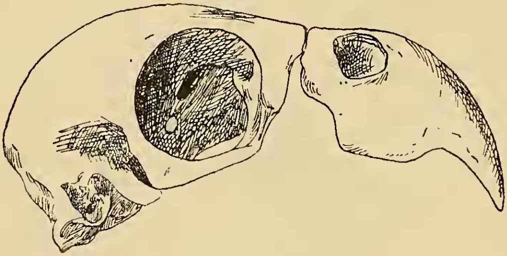
In *Pyrrhura hæmatotis* the orbital ring is complete, as in *C. leucotis*, and the whole skull differs little from the latter species, except that a mandibular fontanelle is present and the interorbital vacuity is unusually large and rounded or less produced posteriorly.

In *Brotogerys* and *Myopsittacus* the orbit is incomplete, and the postfrontal process is in both cases very small, while the squamosal one is of large size. The auditory meatus is narrow, especially in *Myopsittacus*. A mandibular foramen is present and large in *Brotogerys*, absent in the others; the ramus of the mandible is in both longer and its angle less truncated than in the Conures. The nares in *Brotogerys* are even larger than in the Conures, and separated by a very narrow bridge of bone; in *Myopsittacus,* on the other hand, they are unusually small and wide apart.

Family Pioninæ.

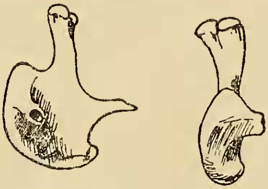
Of this group I have studied *Chrysotis æstiva* (fig. 22), *Pachynus brachyurus, Pionus menstruus* and *P. maximiliani, Caica melanocephala* (fig. 24, p. 31), and *Pœocephalus fuscicapillus* (fig. 26, p. 31). Of these, *Chrysotis* and *Pionus* are markedly different from the rest. In *Chrysotis* the orbital ring is complete, by the fusion of the preorbital and postorbital processes, and the bar thus formed is strong and broad, and forms with its lower border an abrupt descending angle opposite to the extremity of the squamosal processes, which closely approaches it. The latter is broad and massive, and similar in shape to that of *Conurus*; the temporal fossa between the postfrontal and squamosal processes is deep, but unusually narrow. The auditory meatus is wider, its superior and inferior notches are broad and rounded, and the ridge separating it from the quadrate articulation is low and indistinct. The proötic articular surface is

Fig. 22.



Chrysotis æstiva.

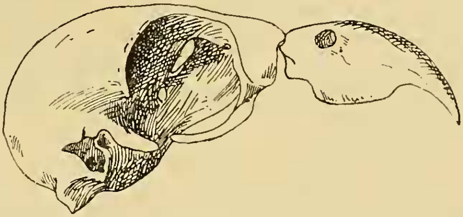
Fig. 23.



Quadrate bone of *Chrysotis æstiva.*

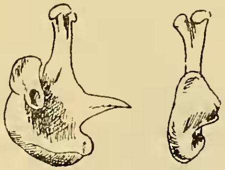
deep, the squamosal large but shallow. The paroccipital wings are continuous with the basitemporal ridges. The ridge running from the supra-occipital region to the outer and posterior margin of the paroccipital process, and separating the posterior from the lateral aspect of the skull, takes a somewhat sinuous course forwards behind the ear, so as to leave between it and the border of the meatus a much narrower interspace than in *Psittacus* and *Eclectus*; the same is true also of *Conurus*. The quadrate is very similar to that of *Conurus*. Descending processes are not present on the hinder border of the maxillæ. There is a small mandibular fenestra.

Fig. 24.



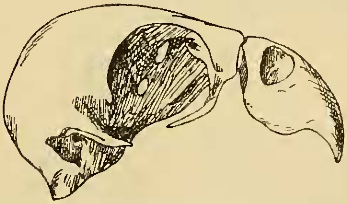
Caica melanocephala.

Fig. 25.



Quadrate bone of *Caica melanocephala.*

Fig. 26.



Pœocephalus fuscicapillus.

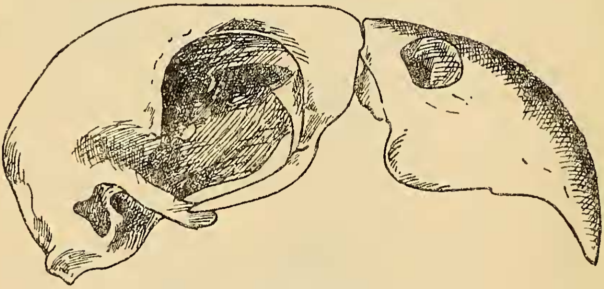
The skull of *Pionus* is very similar. The interspace between the auditory meatus and the occipital ridge is still narrower. A deeper notch separates the paroccipitals from the basitemporal ridges. The shaft of the quadrate is shorter and stouter, and the anterior process more reduced.

In *Pachynus*, *Caica*, and *Pœocephalus* the orbital ring is incomplete, and in all these the postfrontal process is extremely reduced, forming only a short protuberant edge as in *Eclectus*. In all the squamosal process is well developed: it is especially long and straight in *Pachynus*, in which it nearly meets the prefrontal; the latter process is much shorter in *Pœocephalus* than in the other two. In *Pachynus* the basitemporal ridges are faint, and the surfaces external to them and extending back to the paroccipitals are much flattened, the paroccipitals being directed backwards; there is no trace of descending maxillary processes. In *Caica* the basitemporal ridges are much stronger; in all the basitemporal plate is nearly on a level with the occipital condyle. The auditory meatus is somewhat narrower and more notched above and below than in *Chrysotis*, and the interspace between it and the occipital ridge is somewhat greater. The quadrate in *Caica* and *Pachynus* has a high posterior prominence above and behind the socket for the jugal, as in *Conurus*. The mandibular fenestra is large in *Caica*, small or obsolete in the other two.

Family PSITTACINÆ.

The skull of *Ps. erithacus* has been considered already. I have also studied the skulls of *Coracopsis vasa* (fig. 27) and *C. nigra*, and an imperfect specimen of *Dasyptilus pecqueti* (fig. 28).

Fig. 27.



Coracopsis vasa.

The skulls of these Parrots bring us face to face with the problem of whether *Coracopsis* and *Dasyptilus* are rightly placed in so close a relation to *Psittacus*; in other words, with one of the dubious and crucial questions that osteology might suffice to solve. I cannot boast of being able to give a very clear answer to the question, but it seems to me that the skull of *Dasyptilus*, and in a minor degree that also of *Coracopsis*, differs in so many points from that of *Psittacus*, that they go far to show that the little group of *Psittacinæ* is very dubiously or improperly defined.

In *Coracopsis vasa* the postfrontal process is almost obsolete, forming a slight vertical ridge behind which rises the impression of the temporalis muscle. The squamosal process is broad, deeply notched at its base above the quadrate articulation, and the suprameatal process and the flattened or excavated surface in front of it are considerably developed. The auditory meatus is narrow and crescentic, its upper end forming a deep notch. While this notch approximates to the occipital ridge, lower down a broad surface lies between the latter and the meatus. The paroccipital process is extremely short and blunt. The nostrils are large, the mandibular fenestra very large, and the interorbital fenestra small.

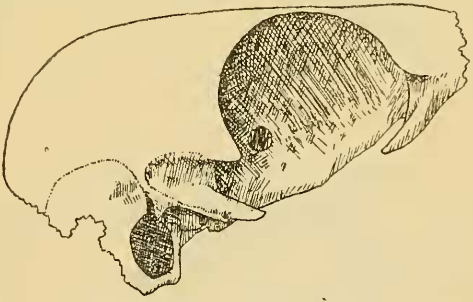
The skull of *C. nigra* agrees in most points with that of *C. vasa*. But the paroccipitals are shorter, rounder, and more expanded; the triangle of the basitemporal plate is more obtuse, and it is less elevated from the level of the occipital condyle.

The mandible has in both species a very large fontanelle.

In *Psittacus* the postfrontal process is stout and prominent though short, the impression of the temporalis muscle elongated, but narrow from above downwards. The squamosal process straight and narrow, devoid of a notch; the suprameatal process ill developed; the auditory meatus moderately wide, its posterior border nearly straight and widely separate from the occipital ridge; the paroccipital process is prominent; the nostril and the interorbital fenestra are both of moderate size; the mandibular fenestra is small.

Of *Dasyptilus pecqueti* (fig. 28) I have only an imperfect skull, removed from a skin; but, as it is, it exhibits characters of considerable interest. The orbit is incomplete, and the prefrontal process even less than in *Psittacus*. The postfrontal is small, and much as in the latter genus. The squamosal is extremely stout and broad, and bears an accessory process and notch on its lower border. The suprameatal tubercle is minute. The auditory meatus is nearly circular, and is surrounded by a strong ring of bone, produced below into a small notch or lip; there is no posterior or superior notch, and in front the ring of bone separates, in an unusually complete way, the auditory cavity from the

Fig. 28.



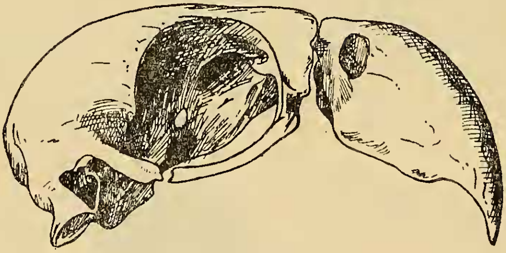
Imperfect skull of *Dasyptilus pecqueti.*

quadrate articulation. The outlines of the temporal and digastric fossæ are, as shown in the diagram, extremely different from those of both *Psittacus* and *Coracopsis*. The shaft of the quadrate is extremely stout, its inner border running down evenly into the mass of bone above the quadrato-jugal cup; the anterior process is short but stout; the inner head of the bone is of exceptional size. Alone among all the forms I have examined, the interorbital vacuity is completely absent. I feel convinced that further examination of better material will show *Dasyptilus* to be a very peculiar and isolated form. *Coracopsis* is very similar to *Eclectus*, and this resemblance will be discussed in dealing with the latter form.

Family PALÆORNITHINÆ.

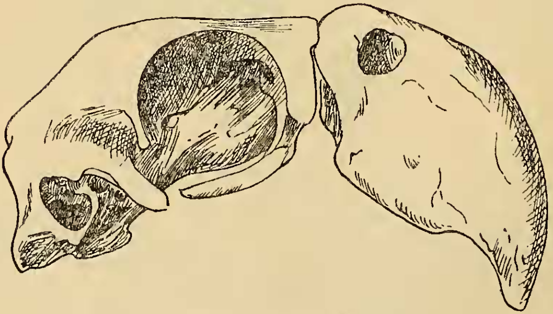
Of the forms grouped as Palæornithinæ, I have studied *Eclectus* (fig. 29), *Geoffroyus*, *Tanygnathus* (figs. 30, 31), *Polytelis* (fig. 32, p. 35), *Aprosmictus* (fig. 33, p. 35), *Pyrrhulopsis* (figs. 34, 35, p. 36), *Agapornis* (fig. 36, p. 37), and *Palæornis*; I regret in particular the want of *Loriculus*. Of these, it is clear that *Polytelis*, *Aprosmictus*, and *Pyrrhulopsis* stand apart from the first

Fig. 29.



Eclectus cardinalis.

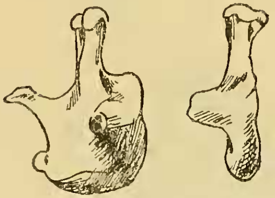
Fig. 30.



Tanygnathus megalorhynchus.

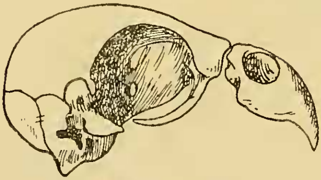
three; while *Agapornis* and *Palæornis* also have peculiar characters. The skulls of *Geoffroyus* and *Eclectus* are extremely alike, in all their leading features: they are, moreover, so similar to that of *Coracopsis*, that their descriptions may be abbreviated. They both have, as in *Coracopsis*, a prefrontal which reaches to, but does not join, the squamosal; a small postfrontal, somewhat larger, however, than in *Coracopsis* and directed more forwards; a raised triangular basitemporal shield, with broad smooth lateral areas reaching back to a sharp and nearly horizontal paramastoid: in both, the lower margin of the auditory meatus is deeply and narrowly notched, the upper and posterior angle somewhat square, especially in *Eclectus*; the temporal fossa narrow and deep. The mandibular fontanelle is distinct but not large.

Fig. 31.



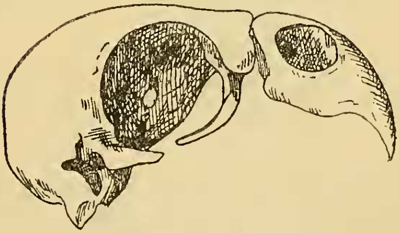
Quadrate bone of *Tanygnathus megalorhynchus.*

Fig. 32.



Polytelis barrabandi.

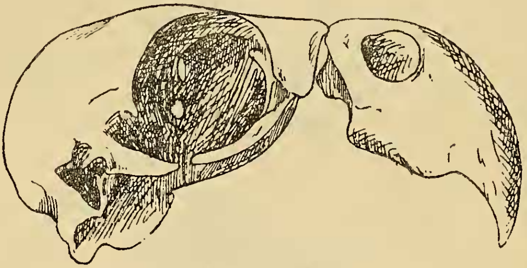
Fig. 33.



Aprosmictus cyanopygius.

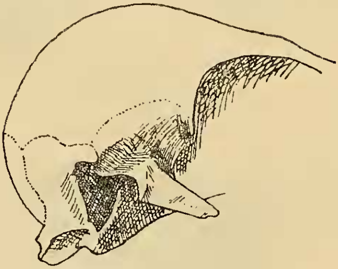
Tanygnathus, while appertaining to the same type, exhibits numerous points of difference. The orbital ring is more widely nterrupted; the postfrontal process is larger and arches downwards; the squamosal process is very stout, and its outer surface is practically continuous with that of the low, broad, suprameatal process. The auditory meatus is wide open and nearly square; the basitemporal plate is much smaller relatively, and scarcely larger actually than in *Geoffroyus*; and the surfaces lateral to it are correspondingly broad. The two heads of the quadrate are confluent; the anterior or pterygoid process of the same bone is unusually large. The mandibular fontanelle is obsolete. The intraorbital fissures are unusually small.

Fig. 34.



Pyrrhulopsis personata.

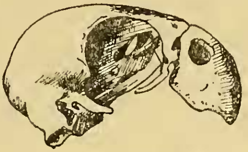
Fig. 35.



Auditory region of *Pyrrhulopsis.*

Pyrrhulopsis, *Aprosmictus*, and *Polytelis* differ from *Tanygnathus* in several points, and particularly in the region of the postorbital and squamosal processes. The postorbital is very indistinctly defined, and exists only as the thickened edge of the descending posterior rim of the orbit, where it meets the temporal fossa. It descends lower in *Aprosmictus* than in *Pyrrhulopsis*, and lower still in *Polytelis*, where it leaves only a slight and narrow groove between it and the squamosal to represent the outlet of the fossa. The configuration of the base of the squamosal process is totally different from that of *Tanygnathus*; for the suprameatal process is now separated by a wide and deep groove from the squamosal, and the latter does not overhang the quadrate, but is excavated to form a deep notch, which exposes the head of the quadrate bone. In all these forms the intraorbital fissure is large, the descending processes from the hinder border of the maxillæ are large also, the inner head of the quadrate is quite distinct, and the mandibular fenestra is obsolete.

Fig. 36.



Agapornis roseicapillus.

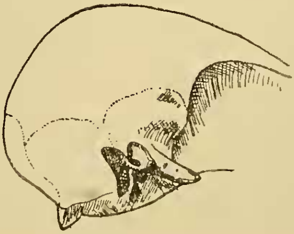
In all, the auditory aperture is much narrowed, by the forward growth of the posterior wall of the meatus; this takes place to the greatest extent in *Polytelis* and *Aprosmictus*, in which last the aperture is reduced to a curved slit. The basitemporal triangle is very small in *Pyrrhulopsis*, and well defined from the areas at its sides; the paroccipital processes, looked at from behind, are nearly vertical; in *Aprosmictus* they are more horizontal, and the lateral areas are accordingly more on a level with and less defined from the basitemporal; in *Polytelis* the same tendency is still more displayed.

In *Agapornis* the orbital ring is incomplete and the postfrontal extremely small, as in the forms last described. There is a notch at the base of the squamosal process, but the latter is not separated by a groove from the suprameatal; the conformation here is more as in *Eclectus*. The auditory meatus is narrow, and the intraorbital vacuity very large. The mandibular fenestra is large also. The quadrate is very delicate in form; its two heads are fused, its shaft is very slender, and its anterior process small.

Family Platycercinæ.

Of this group I have examined skulls of *Platycercus* (fig. 37), *Nanodes (Lathamus) discolor*, *Neophema pulchella*, *Psephotus*, *Nymphi-*

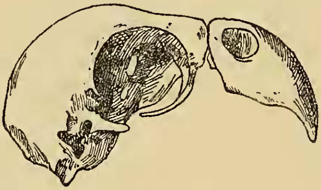
Fig. 37.



Platycercus elegans.

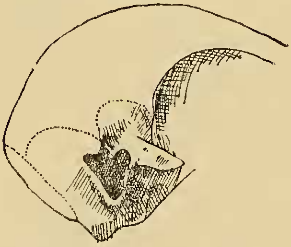
cus (figs. 38, 39), and *Melopsittacus* (fig. 40, p. 39). Of these, the last alone differs markedly from the others. The characters common to the rest are precisely the characters to which I have called attention in *Aprosmictus*, *Polytelis*, and *Pyrrhulopsis*; that is to say, to the Australasian forms described under the group *Palæornithinæ*. In all, we find an incomplete orbital ring, a postfrontal process scarcely represented by more than the raised border of the orbit; a squamosal process crossed at its base by a deep groove above the meatus and in front of the suprameatal process. In all, the auditory meatus is narrow and curved; the intraorbital vacuity is large (especially in *Nymphicus*); the mandibular fenestra is obsolete. In all, the base of the skull is flattened, the small triangular basitemporal plate being nearly on a level with the areas at its sides. The squamosal region presents certain peculiarities in the several forms. In *Platycercus*, at least in Pennant's Parrakeet, the groove above described at the base of the squamosal is bridged by a well-developed ring of bone, extending from the suprameatal process to a slight descending process or tubercle at the base of the squamosal. In *Nymphicus* the groove is extremely deep, and though the bridge of bone is not present, the two processes are very well marked, that at the base of the squamosal being extremely conspicuous. In *Neophema* the postfrontal process is at a minimum, the posterior border of the orbit running with

Fig. 38.



Nymphicus uvæensis.

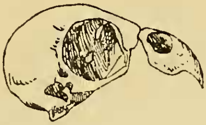
Fig. 39.



Auditory region of *Nymphicus uvæensis* (enlarged).

scarce a perceptible interruption on to the upper border of the squamosal. In *Nymphicus*, the inner head of the quadrate is ill-defined; in *Platycercus* it is separate but very small: in both the shaft is slender, the anterior process very small, and the pterygoid condyle scarcely separate from the mandibular.

Fig. 40.



Melopsittacus undulatus.

In *Melopsittacus* we have a complete orbit, and furthermore a bridge of bone crosses the temporal fossa, uniting the postfrontal process to the squamosal, precisely as in the Cockatoos, though leaving a proportionately small fenestra. The characters of the base of the squamosal region, of the base of the skull, of the intraorbital vacuity, and of the mandible resemble those of the other *Platycercinæ*. The quadrate is very like that of *Nymphicus*. In the hyoid of *Melopsittacus*, by the way, the parahyal processes form an arch, meeting together above the basihyal, precisely as Dr. Mivart has shown in the case of the Lories.

RECAPITULATION.

From the foregoing facts it seems to me easy to draw certain interesting conclusions, though many questions are still left imperfectly answered. In the first place, the isolation of *Nestor* is very evident. The whole character of the squamosal and auditory region of the skull is unique, and unapproached in any other Parrot. The great size of the intraorbital vacuity and of the mandibular fenestra, the shape of the quadrate, as well as the more obvious peculiarities in the shape of the beak and mandible, all distinguish the skull at a glance. There is no osteological ground for allying *Nestor* with the Lories as in Dr. Gadow's scheme, any more than with *Psittacus* and *Ara* as in Garrod's. Its right to constitute a separate family as instituted by Salvadori seems perfectly clear, and indeed Prof. Newton (Dict. of Birds, p. 629) has already remarked that Salvadori's view "is fully justified by a cursory examination of its osteology."

Though less striking at a glance, the cranial peculiarities of *Stringops* are certainly no less important. I am inclined to attach high importance to the characters of the quadrate bone, in which, as I have shown above, the short thick shaft, the large broad anterior process, the great ridge bearing the jugal cup, and the position of the pterygoid condyle, widely separate from the mandibular articular surface, are all unique among the Parrots, in all the rest of which the quadrate, varying within narrow limits, has a form very characteristic of and peculiar to the family. I have no doubt that, in respect to the other Psittaci, this quadrate of *Stringops* is a primitive one—that is to say, it is not to be conceived as formed by a further modification of the typical Parrot's quadrate, but has less of modification than theirs; but at the same time it possesses, though in an ill-formed way, the Psittacine characters, and I cannot draw from it any clue to relationship outside the group. Of all the characters of the Psittacine quadrate, the chief is found in the character of the articulation with the mandible, and the region of this articulation deserves a little further consideration.

It is a characteristic of all Birds that this articulation is a double one. In Reptiles the transversely expanded lower end of the quadrate is crossed by a saddle-shaped groove, and so forms an outer and inner tuberosity, which, however, form one articular surface, playing on an uneven but continuous socket in the articular and sometimes extending outwards on to the angular bone. But in Birds the corresponding groove is deepened, until the condyle, originally single, is divided into two: the inner one lies below and behind the articulation of the quadrate with the pterygoid, the outer one below and internal to the articulation with the jugal (the main difference in the Reptile lying in the extension of that portion of the quadrate intervening between the inner part of the condyle and the pterygoid). The former plays into the deep glenoid cavity, more or less elongated in an antero-posterior direction, on the inner side of the jaw; the latter plays on a no less well-marked surface on the outer margin of the jaw. In *Apteryx* we see these two very clearly, and they are both remarkable for their transverse form and position, with a minimum of antero-posterior elongation. In *Struthio* we find the outer, or (for convenience) the sub-jugal condyle, produced backwards into a well-marked and somewhat hollowed articular surface immediately below the shaft of the bone, and these two portions play into an enlarged area along the outer border of the mandible, quite distinct from the inner or true glenoid cavity.

In the Raven the state of matters is not dissimilar, but the outer articulation, as it were increasing in importance, now, in its posterior extension, runs backward very nearly to the posterior angle of the jaw. In *Dacelo* this posterior portion of the outer condyle is developed into a separate tubercle little less than the anterior one, and the facet on the mandible is divided into two portions accordingly. With various slight modifications, a similar condition is found in very many other birds, and in the Herons we reach an extreme development of the posterior (and outer) condyle, now separated by a deep hollow (to which, in the mandible, a high ridge corresponds) from the anterior portion. The more this posterior area becomes enlarged and separated from the anterior, the more in certain cases it becomes approximated to the inner (or sub-pterygoid) condyle, though, so far as I can see, the corresponding surfaces in the mandible remain distinct. Thus both in the Herons, in some Raptores (*e.g.* the Condor), in the Gulls, and also in *Dacelo*, in a greater or less degree, the two areas become connected, with less or more interruption, by a definite ridge.

Now in the Parrots the inner or sub-pterygoid condyle becomes so extremely enlarged and so elongated from before backwards, that at first sight it appears to form the entire articulation. With its antero-posterior extension it has also undergone a downward expansion, while the region of the bone below the jugal cup is not only thereby raised far above the level of the inner (or true) condyle, but at the same time becomes much less prominent in the outward or lateral direction. This is one of the respects in which *Stringops* seems to have undergone less modification than the others, for the region bearing the jugal cup is very prominent laterally and less raised than in the others above the level of the main condyle. We have seen that more or less in all Parrots the edge of the mandible plays upon the side of the quadrate below the jugal cup, and we now recognize that this is not a new and fortuitous contact, but a more or less obsolete survival of what in Birds in general is one-half of the primitive articulation.

In the Cockatoos, especially in *Microglossa*, and in the Macaws, this articular facet below the jugal cup is quite distinct, and in *Stringops* it is also well-marked and points downwards; in *Microglossa*, where the jugal region of the quadrate is also prominent, though less so, it likewise looks more or less downwards, while in the Macaws and others it lies on a more nearly vertical slope.

It is more difficult to determine how or to what extent *the posterior extension* of this outer condyle, that we have seen to be so well-marked in many birds, is represented in the Parrots. We might be inclined to imagine, from the manner in which it sometimes comes, as I have described above, to approximate with the inner condyle, that the large size of the latter in the Parrots was due to a fusion of the two; but the absence of any change in the relations of the corresponding cavity in the mandible forbids me to think so. I take it that this portion of the quadrate is still represented by that region of the bone immediately behind the pterygoid cup which, reduced or truncated in most Parrots, is comparatively prominent in *Stringops*. And although this area no longer serves an articular purpose, I think we may recognize it (both in its more highly developed form in *Stringops*, and in the shape of a smaller tubercle in *Ara* and *Microglossa* and of an elevated protuberance in *Conurus* &c.) by its relations to the quadrato-jugal cup, behind which it lies, and to the region bearing the main condyle which curves evenly backwards towards it.

I have already shown that in its complete orbit, formed by a junction of the prefrontal and postfrontal elements, *Stringops* is unique among the Old-World Parrots; its temporal fossa is disproportionately large compared with all the rest; the grooved surface posterior to the squamoso-temporal articulation and overhung by the suprameatal process is by far more developed than in any other Parrot except *Nestor*, though in this respect *Stringops* itself is far from approaching that peculiar type, and such resemblance as this region shows does not amount to an indication of affinity between the two outlying forms. On the whole, the facts in our possession seem to confirm the right of both genera to represent separate families very distinct from the other Psittaci, and there is more evidence in the skull of *Stringops* than in that of *Nestor* of low or primitive characters. In spite of its complete orbit I am inclined to think it the lowest or least modified of a highly modified group, and to look upon *Nestor* as an aberrant but less primitive form, to which, however, I cannot assign a direct connection with, or derivation from, any other known genus.

The Cockatoos are for the most part distinguished by a complete orbit, and by the fusion of the suborbital bar both with the postfrontal and with the squamosal process, so that a bridge is formed across the temporal fossa (*cf.* Garrod, P. Z. S. 1874, p. 594); where the temporal fossa is incompletely bridged, as in *Microglossa* and in *Cacatua ducorpsii*, a posterior ramus extends backwards, apparently from the postfrontal part of the suborbital bar, to bridge it incompletely. The shaft of the quadrate is stout, the region bearing the jugal cup is elevated, and the external or subjugal articular surface comparatively well-marked. The interorbital septum is deep and truncated or indented anteriorly. The auditory meatus is on the whole wide, and its posterior border is always very near to the occipital ridge. The external nares are round, and comparatively small, sometimes, as in *Microglossa*, very small indeed.

Calopsittacus is, in the character of its orbital ring, thoroughly Cacatuine; but it differs in its larger and more oval nostrils, and in a greater narrowing of the auditory meatus by reason of the ingrowth of its posterior wall, which leads to an extension of the interspace between the meatus and the occipital ridge. *Cacatua roseicapilla* forms in both respects an intermediate stage.

The only other Parrot in which the temporal fossa is bridged by bone, so far as I know, is *Melopsittacus*, though here the squamosal process is much broader and flatter, and the temporal fossa much smaller than in *Calopsittacus*. The two skulls, however, show a strong resemblance one to another.

With the exception of *Melopsittacus*, the whole group of Australian Parrots united under the name *Platycercinæ* agree, so far as I have examined them (and I particularly regret the want of *Pezoporus* and *Geopsittacus*), in several distinctive characters. The Australian genera *Polytelis*, *Aprosmictus*, and *Pyrrhulopsis* (and I expect *Ptistes* also) agree so perfectly in cranial characters with the *Platycercinæ*, that I do not doubt for a moment the necessity of removing them from the *Palæornithinæ* and uniting them with the other Australian genera. The leading character in all these forms is the presence of a deep groove or excavation at the base of the squamosal process, the area overhung by the suprameatal process being confluent with the temporal fossa. The auditory cavity is clearly bounded in front and separated from the region of the quadrate articulation by a bar of bone confluent above with this region in front of the suprameatal process. There is further a well-marked notch on the lower margin of the squamosal process at the place of the quadrate articulation, much as in *Stringops*. The auditory meatus is very narrow and crescentic in form; the space between it and the descending occipital ridge is very wide; the basitemporal region is nearly on a level with the occipital condyle; the paroccipital process is blunt (except in *Pyrrhulopsis*); the orbital ring is incomplete and the postfrontal process almost obsolete or represented only by a vertical ridge; the nostril is large, the interorbital fenestra is moderately so, the mandibular fenestra is extremely small or obsolete. While *Melopsittacus* appears to differ most markedly from the above in its complete orbital ring, with its bridge, as in the Cockatoos, across the temporal fossa, yet at the same time it possesses an extremely well-marked notch at the base of the squamosal and a deeply-excavated surface between this and the suprameatal tubercle; it agrees in all the other characters mentioned above with the *Platycercinæ*, of which I have no doubt it is a real, though a somewhat aberrant, member.

The case of *Calopsittacus* is a little more difficult. While in the Cockatoos the auditory meatus reaches backward to the descending occipital ridge, in *Calopsittacus* as in *Melopsittacus* there is a wide interspace between. The auditory meatus is proportionately narrower than in the Cockatoos. The temporal fossa, though bridged by bone as in the Cockatoos, is much smaller and narrower than in them. There is a very distinct notch at the base of the squamosal and a well-marked surface between it and the suprameatal process, though this is not nearly so conspicuous a feature as in the *Platycercinæ*. The nostrils are very large and near together as in *Melopsittacus*, and are very different from the small, round, and distant nostrils of the Cockatoos. On the whole I should say that, so far as cranial osteology goes, the position of *Calopsittacus* is an open question, and that it is by no means impossible that it may really deserve to be grouped somewhere near *Nymphicus* and *Melopsittacus*. While the facts suggest at least the possibility of a closer affinity than that usually recognized between the two Australian groups of *Cacatuinæ* and *Platycercinæ*, this larger question must also remain for the meantime in uncertainty.

The true Lories form a natural group, and their place is, I believe, not far from the *Platycercinæ*. The auditory meatus is constricted, its posterior border is crescentic and widely separated from the occipital ridge. The orbit is incomplete and the postfrontal process almost obsolete or (as in *Eos*) narrow and vertical. The squamosal process is more or less distinctly notched at its base, more in *Lorius*, much less in *Trichoglossus*, and the well-marked suprameatal process overhangs a surface of bone, to which ascends, as in *Aprosmictus* &c., the bar which separates the auditory cavity from the region of the quadrate articulation. The excavated region of the base of the squamosal is not nearly so complete as in the *Platycercinæ*, but yet it is more like to them than to any other family of Parrots.

The three genera grouped by Salvadori as *Psittacinæ*, namely

Psittacus, *Coracopsis*, and *Dasyptilus*, are very different from one another in regard to their skulls. *Coracopsis* appears to show a marked resemblance to *Eclectus* and *Geoffroyus*. As to *Dasyptilus*, it is certainly very different from both *Coracopsis* and *Psittacus*: the characters of our imperfect specimen suggest no close alliance with other forms, but go some way to indicate a very isolated position for the genus.

The skull of *Agapornis* differs very materially from that of the typical *Palæornithinæ*. The difference is, in the first place, conspicuous in the extremely narrow auditory meatus and extremely wide, almost square, surface between its straight posterior border and the descending occipital ridge. The suprameatal tubercle is moderately developed, the squamosal process long and curved, the postfrontal process extremely small, the nostrils and the interorbital and mandibular fenestræ all large. It is for one thing plain, from the breadth of its post-auditory region, that *Agapornis* differs greatly from the ordinary South-American Parrots. I regret that I have not been able to examine the skull of *Psittacula*, for it would be extremely interesting to see whether this osteological feature confirms (like the characters of the carotids) the separation of these two superficially similar but geographically distinct genera.

Extremely different from all the Parrots of the Old World and very similar to one another are the two genera *Chrysotis* and *Pionus*. The orbit is complete by junction of the prefrontal and postfrontal processes, and the bridge of bone so formed descends to form an angular prominence opposite the extremity of the squamosal. The temporal fossa is extremely narrow. The inferior border of the squamosal is curved but not notched. The suprameatal tubercle is low, the auditory aperture wide, and its posterior border is very near to the occipital ridge which bends forward in a sinuous curve to approach it. The paroccipital processes are prominent but flattened or excavated below externally to the basitemporal ridges. The nostrils are of moderate size, the interorbital fenestræ small, and the mandibular fenestra nearly obsolete. Of the genera grouped with these by Salvadori under the name *Pioninæ*, I find *Pachynus*, *Caica*, and the African *Pœocephalus* to be very different. *Caica*, in the extremely small size, circular form, and wide distance apart of its nostrils, resembles *Myopsittacus*, which latter is usually grouped with the Conures. In their other characters *Caica* and *Myopsittacus* are very similar to one another. The postfrontal process is short and nearly vertical, especially in *Caica*. The squamosal process is curved in its lower border and more or less distinctly notched at its base. The suprameatal tubercle is distinct, the auditory meatus rather wide and its posterior border somewhat further from the occipital ridge than in *Chrysotis* and much farther than in *Conurus*. The paroccipital process is very much as in *Chrysotis*; the long prefrontal process much as in *Conurus*. The interorbital fenestra is of moderate size;

the mandibular fenestra differs in the two genera, being obsolete in *Myopsittacus*, but large in *Caica*.

In *Conurus* and *Pyrrhura* the orbit is sometimes complete, though the suborbital bar when complete is slender; when it is incomplete the postfrontal process is long, as long or nearly so as the squamosal and very much longer than in any of the Old-World Parrots. The squamosal process is curved below but indistinctly notched, the suprameatal process is extremely small, the auditory meatus is uncommonly wide and its posterior border is very near to the occipital ridge. The paroccipital processes are prominent and more vertical than in *Chrysotis*. The nostrils are of moderate size, rounded, and somewhat distant, being intermediate in all three respects between *Chrysotis* and *Myopsittacus*. The interorbital vacuity is considerably larger than in *Chrysotis* or *Pionus*. The mandibular fenestra is variable, sometimes large and sometimes obsolete.

There remain to be considered a small number of genera between which I find it harder to draw osteological distinctions or to trace definite resemblances to those already considered. These forms include *Palæornis*, *Tanygnathus*, *Eclectus*, and *Geoffroyus*—in other words, the remaining genera of the so-called *Palæornithinæ* after removing from that family *Agapornis* and the Australian genera allied to *Aprosmictus*; and also *Pachynus* and *Brotogerys*, at present grouped respectively with the *Pioninæ* and the *Conurinæ*, *Pœocephalus*, the African genus grouped with the otherwise exclusively South-American *Pioninæ*, and *Coracopsis*, associated by Salvadori with *Psittacus*. The above genera have all an incomplete orbit and an extremely small postfrontal process in the shape of a more or less vertical ridge. The prefrontal process is long, and it extends close to, though it is not united with, the tip of the long straight squamosal process. The auditory meatus is comparatively wide; the area between it and the occipital ridge is broader than in *Conurus* or *Chrysotis*, but narrower than in *Psittacus* or the Lories, and *à fortiori* much narrower than in *Agapornis*. There is no notch below (except in *Coracopsis*) nor groove across the base of the squamosal process.

The skulls of *Palæornis* and *Tanygnathus* are extremely alike, the only conspicuous difference being in the nostrils, which in *Tanygnathus* are smaller and wider apart. In both genera the interorbital vacuity is extremely small and similar in character. In *Eclectus* the interorbital vacuity is moderately large, the squamosal process is expanded towards its tip, the nostrils are small and oval with the long axis of the oval vertical, and the descending occipital ridge is faintly marked (whereas in the others it was extremely strong) and curves forwards, giving a distinctly different outline to the post-auditory area in front of it. In *Geoffroyus*, with no very important differences perhaps from *Eclectus*, there is less identity of characters than we should expect to find from the very close association in which it is customary to place the two genera.

The nostrils are much larger even than in *Palæornis* and as near together, the interorbital vacuity is large, the squamosal is not expanded distally, the temporal fossa is small, the auditory meatus is narrower, and the post-auditory area broader than in any of these other three genera of *Palæornithinæ*.

The skull of *Pachynus* differs from that of *Chrysotis* and *Pionus* (between which it is placed by Salvadori) in its incomplete orbit and its extremely rudimentary postorbital process. The squamosal process is straighter and narrower, and the post-auditory area somewhat broader.

Brotogerys likewise differs from *Conurus* in its larger and more approximate nostrils, its very small postorbital process, and its more expanded post-auditory area.

The skull of *Pœocephalus* has large nostrils, a small postorbital process, a straight, rather short, squamosal. It certainly differs in these respects from its supposed ally *Caica*. The post-auditory region is extremely tumid, and the crescentic border of the meatus forms a deep notch above. I am unable to draw from the cranial characters of this genus any clear inference as to its closer relationships.

3. Report on the Gorgonacean Corals collected by Mr. J. Stanley Gardiner at Funafuti. By Isa L. Hiles, B.Sc. (Vict.), Owens College, Manchester.[1]

[Received November 2, 1898.]

(Plates I.–IV.)

Of the forms of Gorgonacean Corals sent to me by Mr. Gardiner for identification and examination the majority belong to the family Muriceidæ.

There is one Gorgonellid—*Verrucella granifera* Kölliker; two Sclerogorgic forms of Gorgonidæ—*Suberogorgia verriculata* Esper, and *Keroeides koreni* Wright & Studer; and one Plexaurid, *Euplexaura antipathes* Klunzinger.

Among the representatives of the Muriceidæ there are three new forms—*Villogorgia rubra*, *Acamptogorgia spinosa*, and *Muricella flexilis*.

The specimens have been very carefully preserved in spirit, but unfortunately in some cases the endoderm is not complete, and therefore they are not so useful for anatomical examination as they would otherwise be.

I am much indebted to Professor Hickson for the great help he has given me, especially with regard to the literature. The classification adopted is that used by Wright and Studer in the 'Challenger' Report on Alcyonaria.

---

[1] Communicated by Prof. Sydney J. Hickson, F.R.S., F.Z.S.